Images courtesy of Ennead Architects

Jonathan Coan
AE Senior Thesis
April 10, 2012

Weill Cornell Medical Research Building
New York, NY

Presentation Outline

- Introduction
- Existing Structure
- Thesis Goals
- Structural Depth
- Enclosure Breadth
- Conclusion

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General Building Data

- **Building Name:** Weill Cornell Medical Research Building
- **Location**: 413 East 69th Street, New York, NY 10021
- **Occupant:** Weill Cornell Medical College
- **Occupancy Type:** Laboratory/Research facility
- **Size:** 455,000 square feet
- **Number of Stories**: Below Grade – 3
- Above Grade – 18 + penthouse
- **Dates of Construction**: 2010 – 2014
- **Overall Cost:** $650 Million
- **Delivery Method:** Design-Bid-Build

Project Team

- **Architect:** Ennead Architects
- **Structural Engineer**: Severud Associates
- **Mechanical Engineer:** Jaros Baum & Bolles
- **Laboratory Consultant:** Jacobs Consultancy GPR
- **Construction Manager:** Tishman Construction

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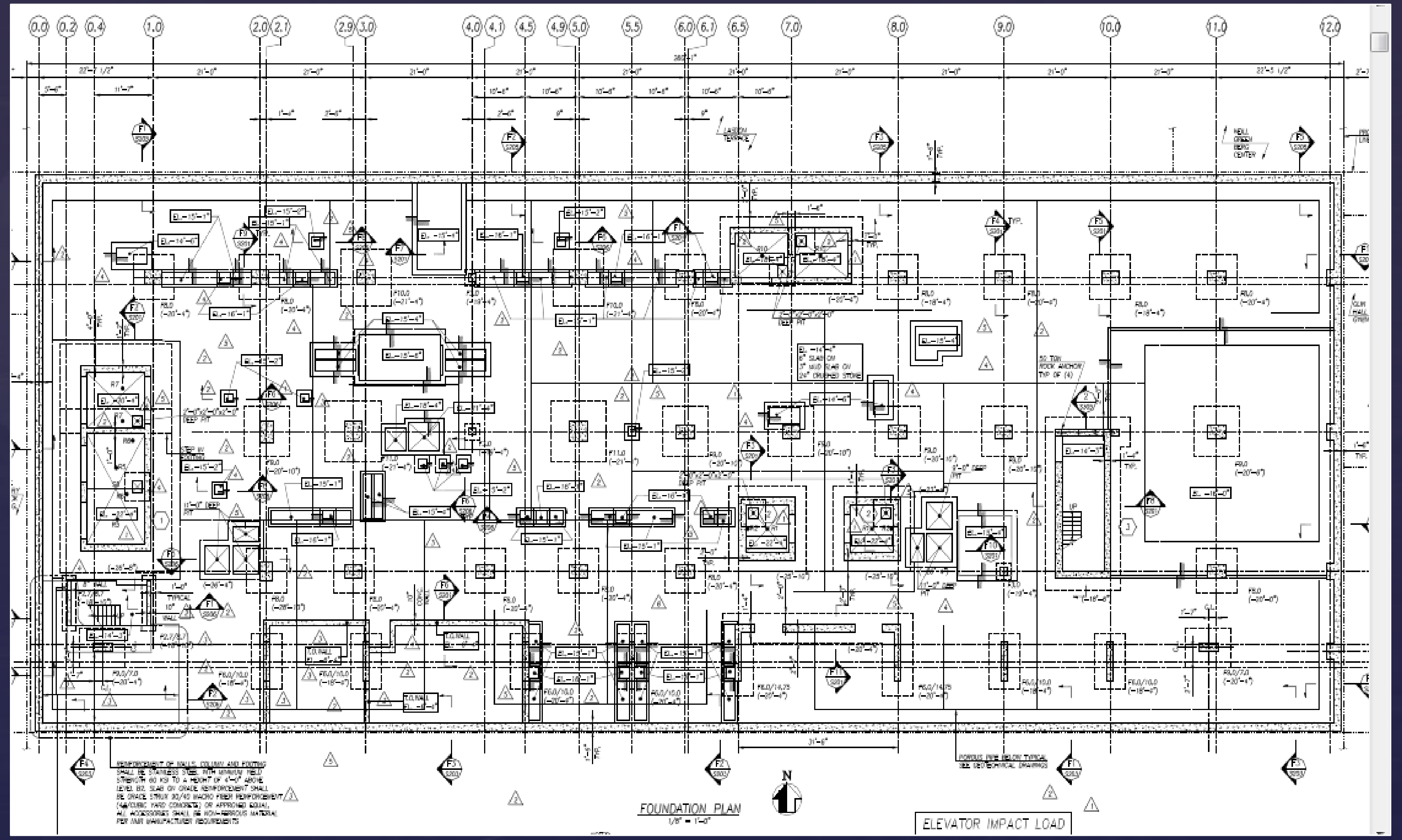
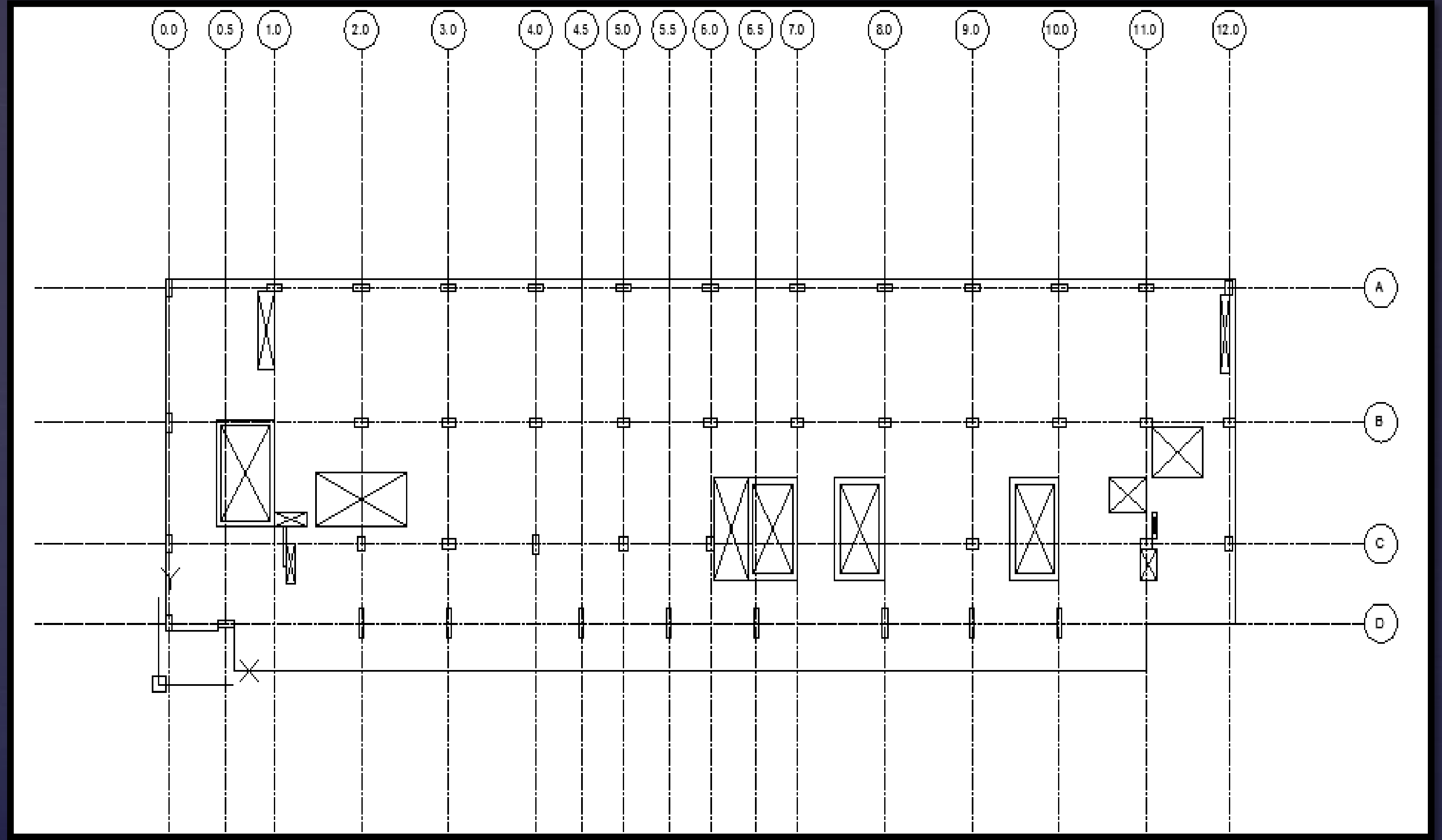
Existing Foundation

- Spread footings on undisturbed bedrock
- Slab on grade 6” resting on 3” mud slab on 24” of crushed stone
- Water table uplift an issue
- (4) 50 ton rock anchors



Basement Floor Plan



Typical Floor Plan

Existing Floor System

- 2-Way Flat Plate Slab
- Typical thickness: 12.5”
- Cantilever in front, 9’-8”
- Slab cambered 5/8” for deflections

Vibrations

- Laboratories sensitive to vibrations
- Floors limited to 2000 micro-inches per second
- HSS members on alternate floors to tie slabs together vibrationally

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Thesis Goals

Structural Depth

- Redesign floor system
  - Eliminate camber
  - Minimize floor-to-floor heights
  - Satisfy deflection requirements
- Column Investigations
  - Change size of 14 x 72 columns
  - Remove Row B columns

Enclosure Breadths

- Redesign Brick Cavity Wall system
- Conduct heat transfer and moisture analysis for comparison of enclosure systems (Mechanical)
- Compare architectural features of each system (Architecture)

MAE Course Related Study

Information, methods, and tools from AE 542 (Building Enclosure Science and Design) used for enclosure breadths

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Structural Depth

Floors Used for Redesign

- 3 – 16 structurally identical = Typical Floor
- 17th Floor
- 18th Floor

Level	Dead Load (psf)	Live Load (psf)
Typical Floor	27, 47	60, 150
17th Floor	97	150
18th Floor	107	400

Other Parameters

- f'_c = 4000 psi

Banded Beam System

- Uniform one-way slab with thickened portion called "band-beam"
- Span Conditions:
  - Typical Span of Typical Floor
  - End Span of Typical Floor
  - Higher Load Areas of Typical Floor
  - 17th Floor
  - 18th Floor
- Reinforcement: Grade 250 Seven-wire Strands

Banded Beam System

One-Way Prestressed Slab

- Pre-stress losses assumed to be 15%
- L/45 used for initial thickness

Location	Superimposed Dead Load (psf)	Live Load (psf)	Thickness (in)	Prestressing	Spacing (in)
Typical Span	27	60	8	18 - .196"	17
Typical Floor (End Span)	27	60	8	18 - .196"	15
Higher Load Areas	47	150	8	18 - .196"	15
17th Floor	97	150	10	18 - .196"	20
18th Floor	107	400	14	18 - .196"	15.50

Band-Beams

- Width: 6ft
- Bundles of (12) 3/8” strands

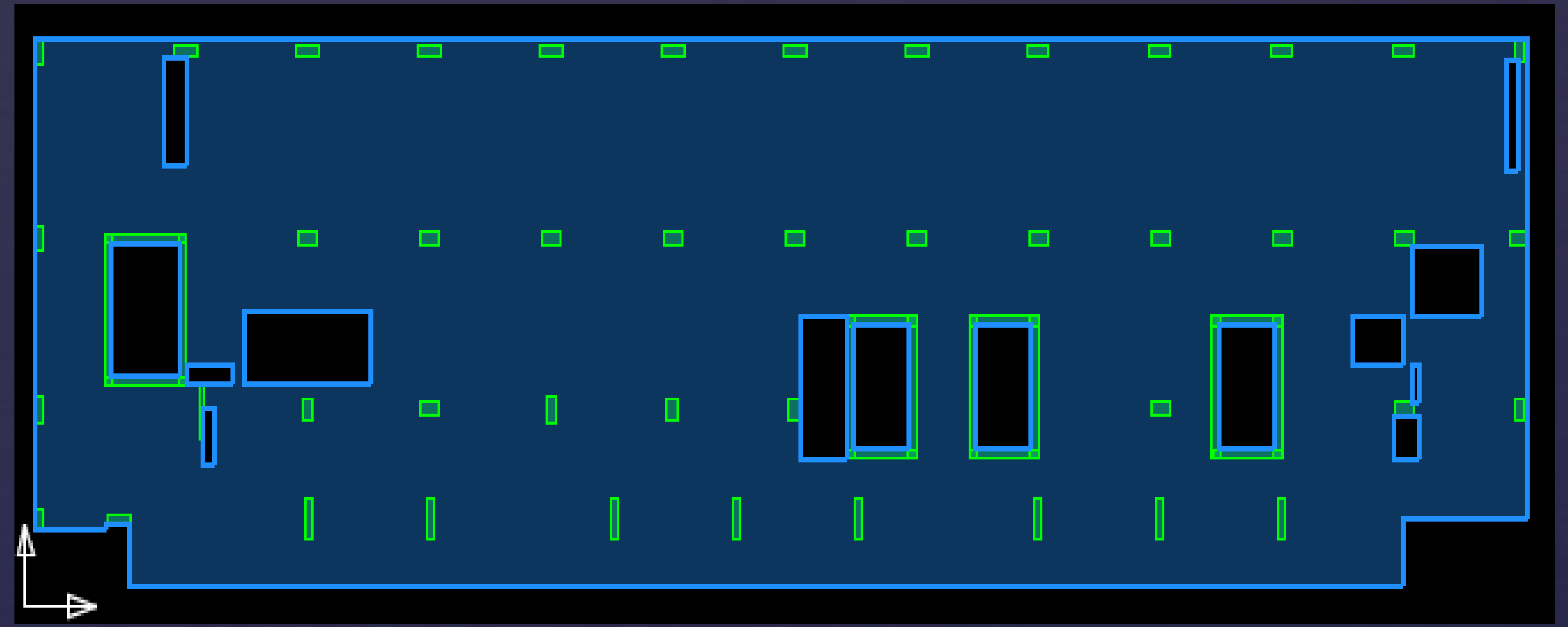
Location	Superimposed Dead Load (psf)	Live Load (psf)	Beam Height (in)	Reinforcement Depth (in)	A_p (in^2)	Tendon Spacing (in O.C.)	M_u (kip-ft)	ϕM_n (kip -ft)
Typical	27	60	14	11.5	5.76	12	351	787
Edge Beam	27	60	14	11.5	2.88	24	232	393
Cantilever	27	60	14	11.5	5.76	12	294	787
Higher Load Areas	47	150	14	11.5	5.76	12	574	787
17th Floor	97	150	14	11.5	5.76	12	654	787
18th Floor	107	400	16	13.5	11.52	6	1214	1360

Two-Way PT Flat Plate Slab

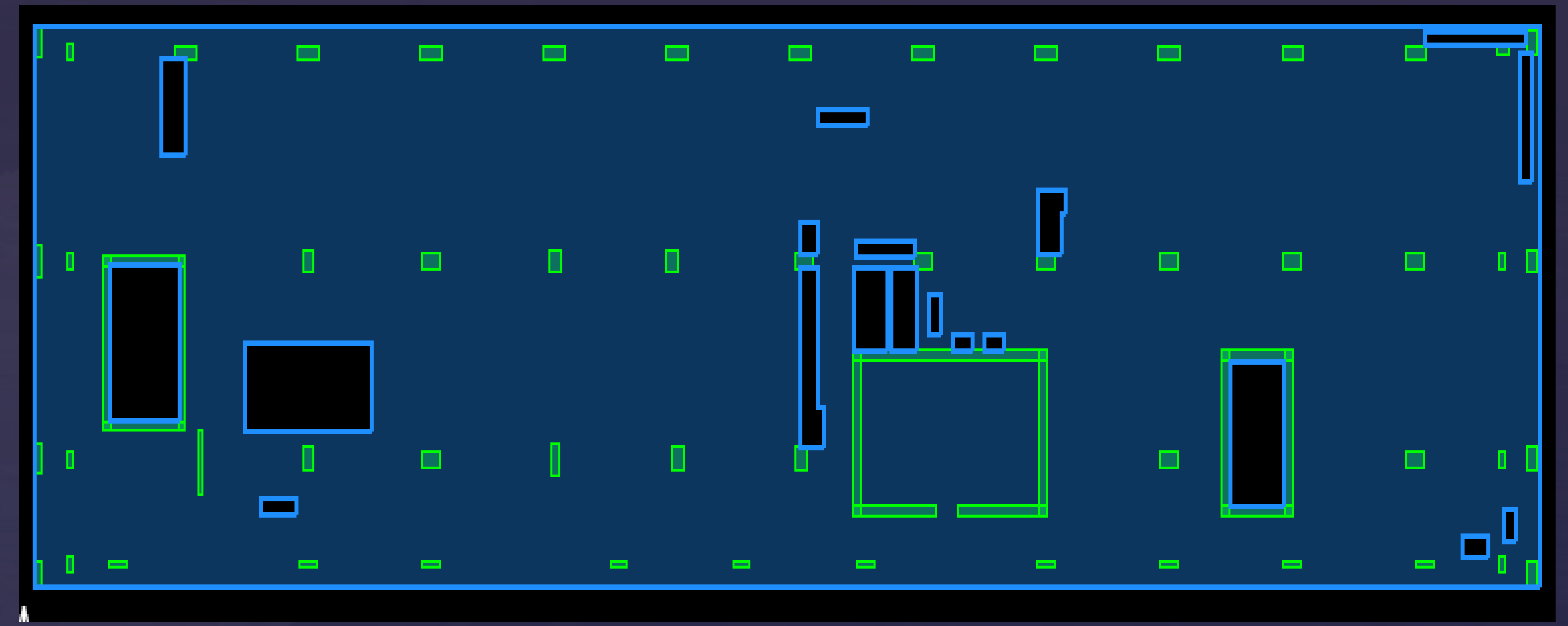
Process

- RAM Concept
- 10" slab thickness
- Bundles of (12) 1/2" strands
- Minimum clear cover top and bottom: 1.5"
- Latitude and Longitude prestressing

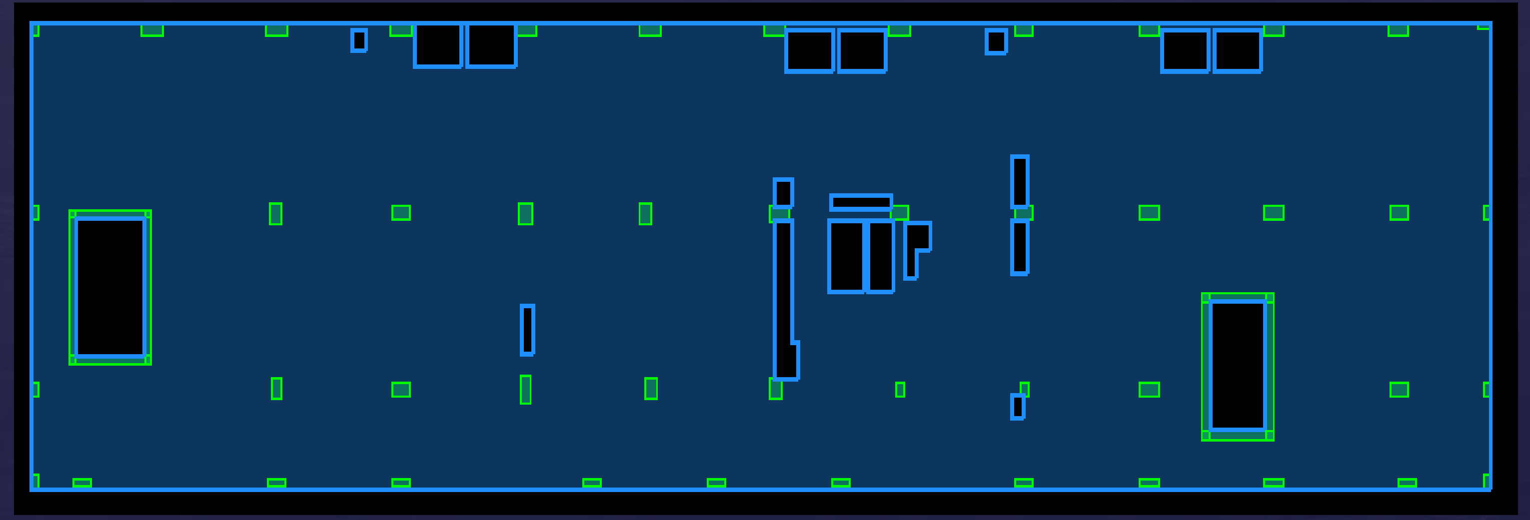
Typical Floor Plan



17th Floor Plan

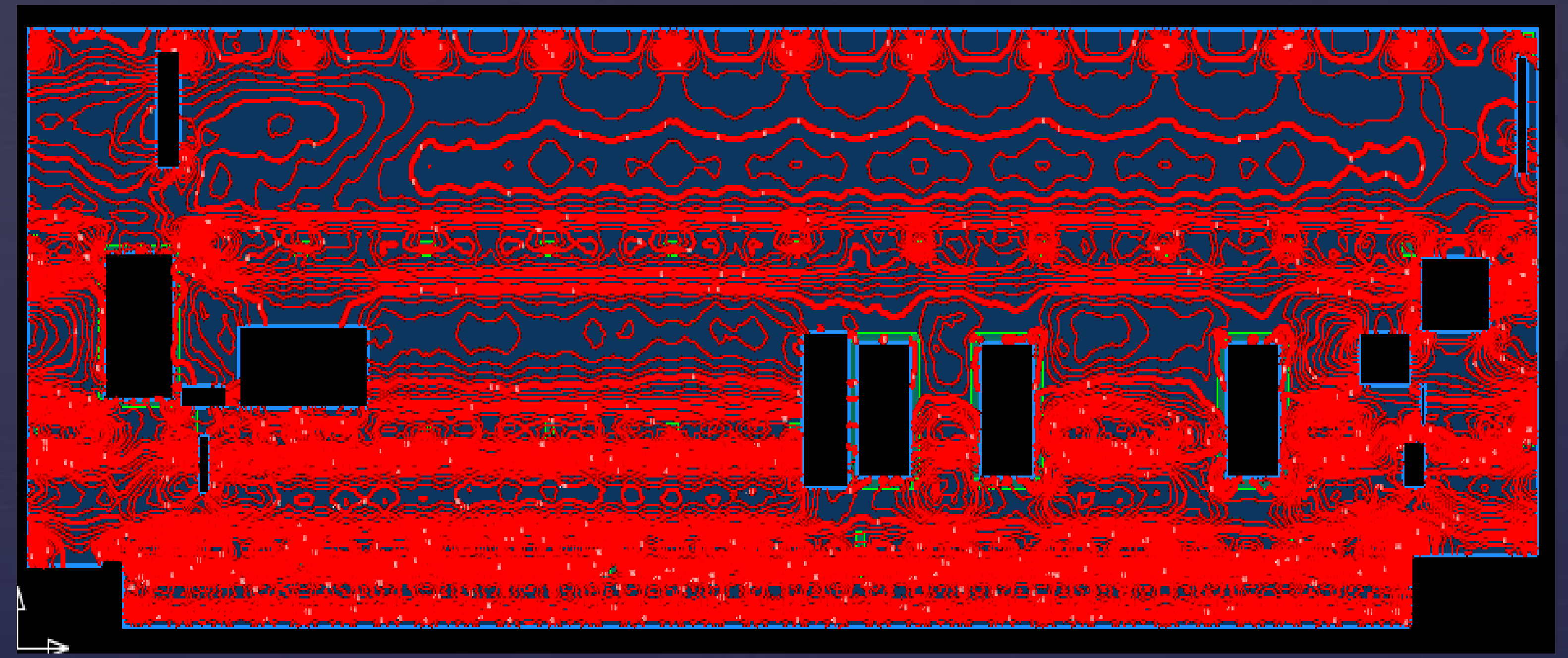


18th Floor Plan

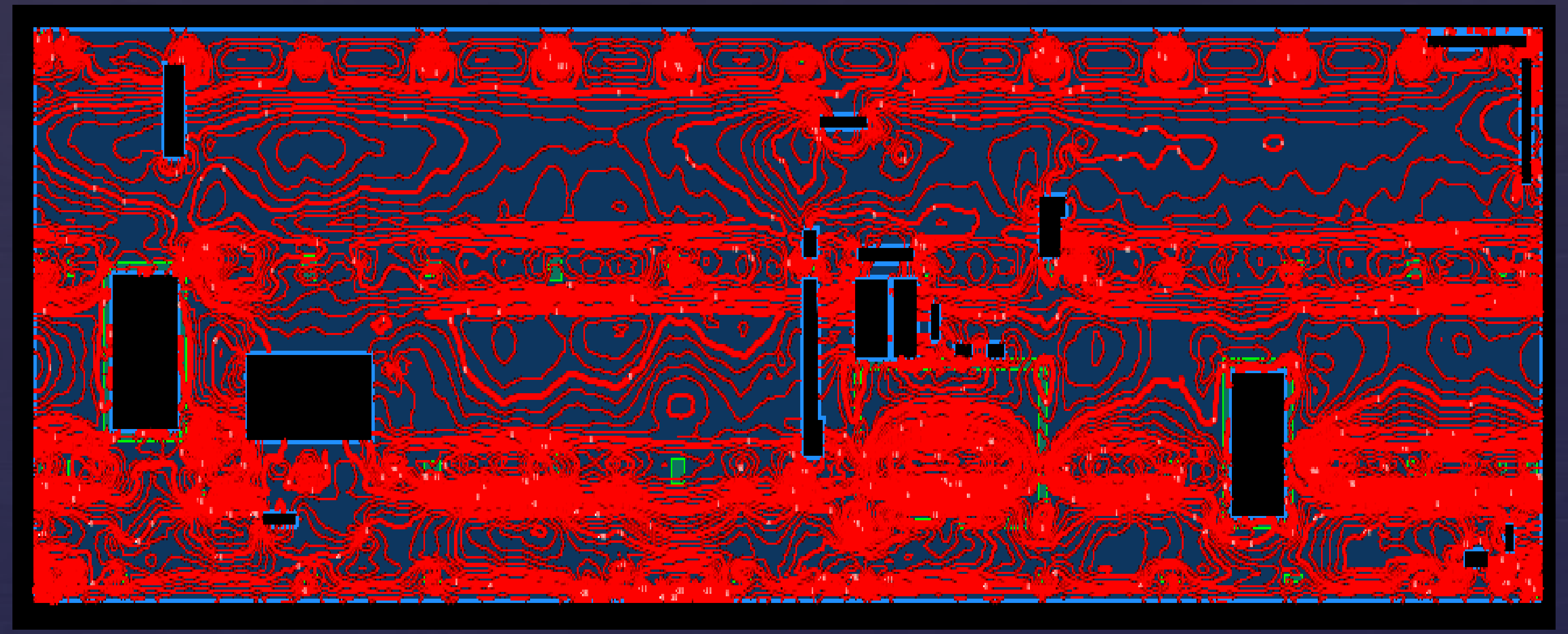


Two-Way PT Flat Plate Slab Maximum Moments

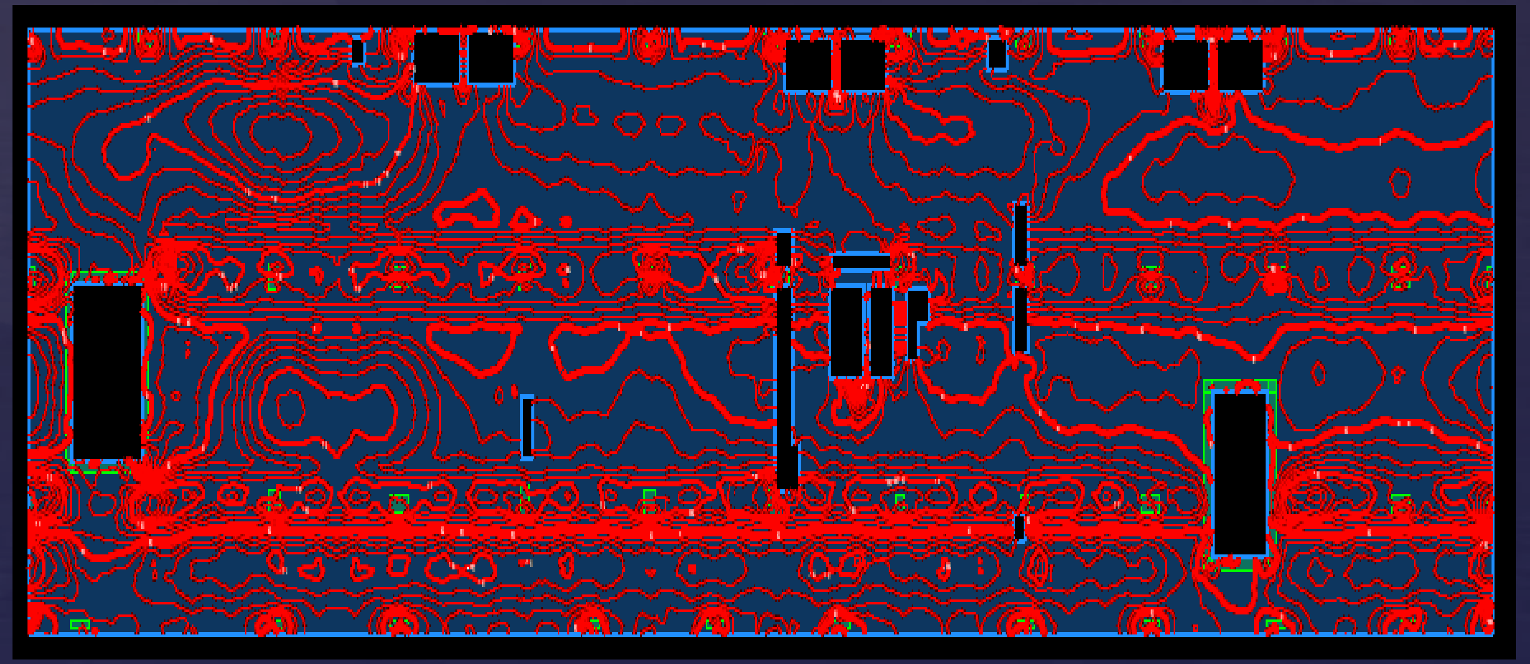
Typical Floor: M_{max} = 500 kip-ft



17th Floor: M_{max} = 850 kip-ft

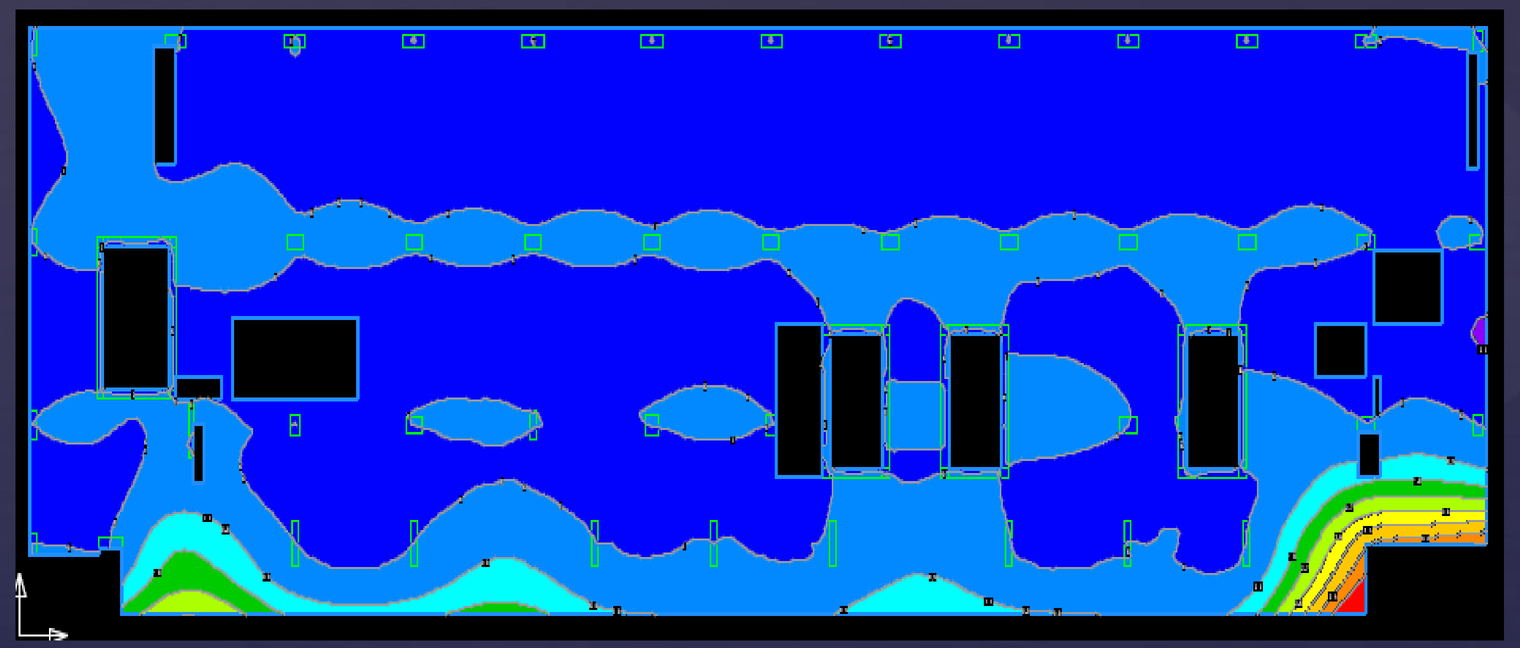


18th Floor: M_{max} = 1000 kip-ft

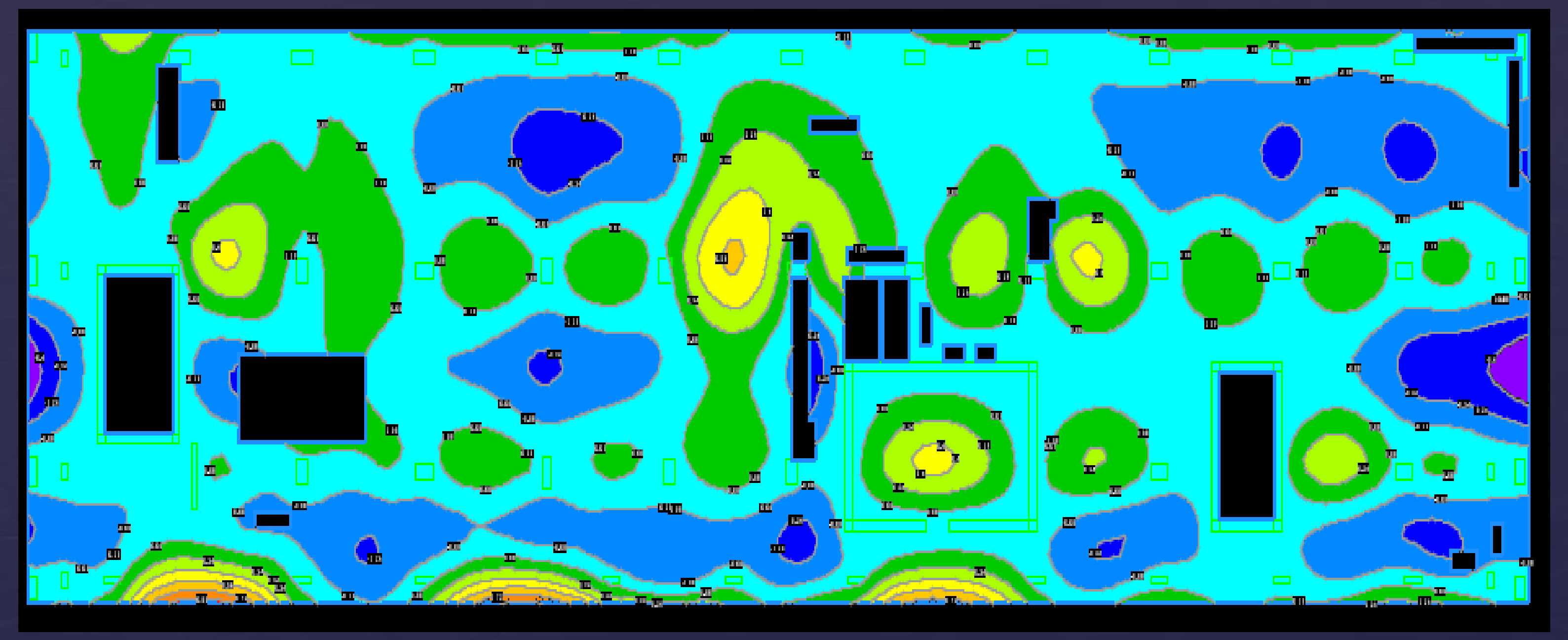


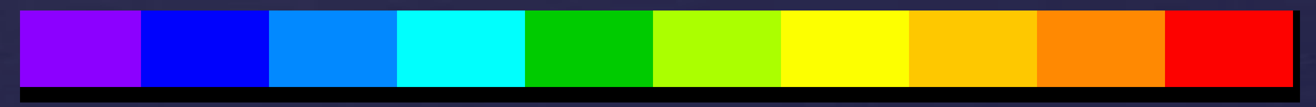
Two-Way PT Flat Plate Slab Deflections

Typical Floor: Δ_{max} = .225 in



17[th] Floor: Δ_{max} = .24 in





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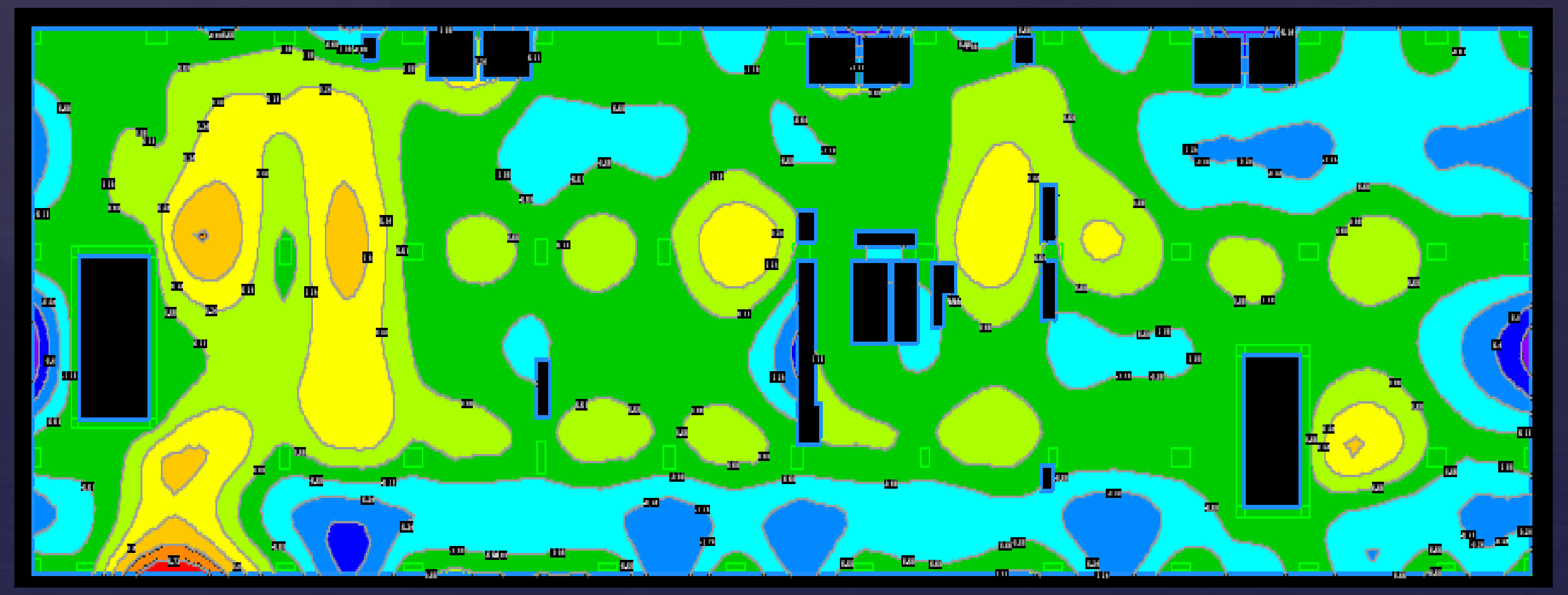
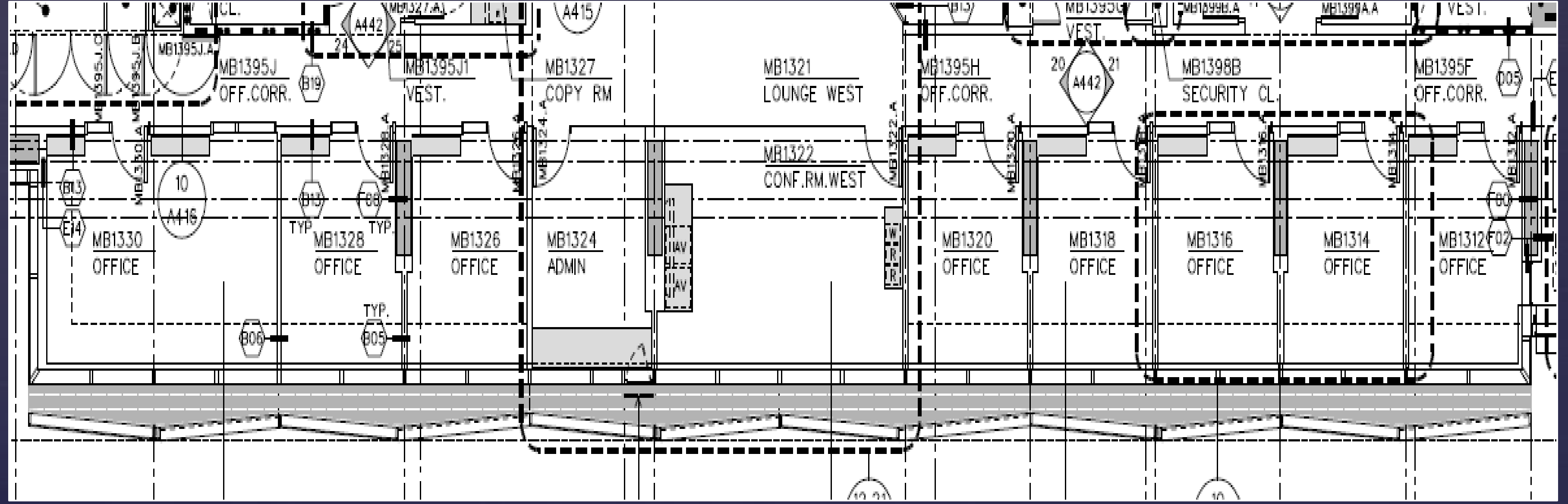


Column Investigations

14 x 72 Column

- Not just a column, not quite a wall
- Works well with floor plan layout

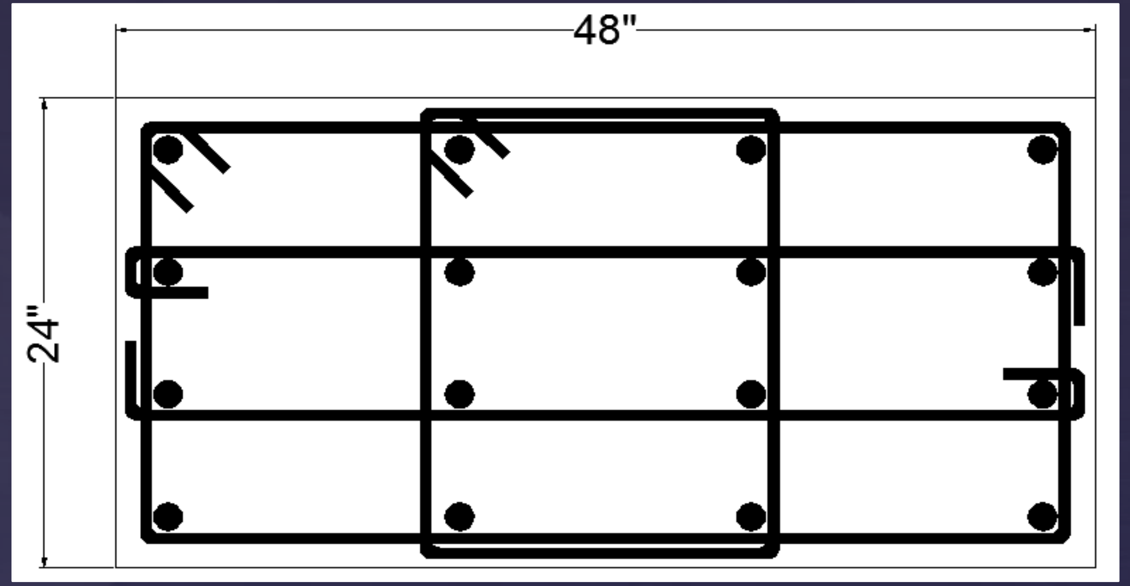


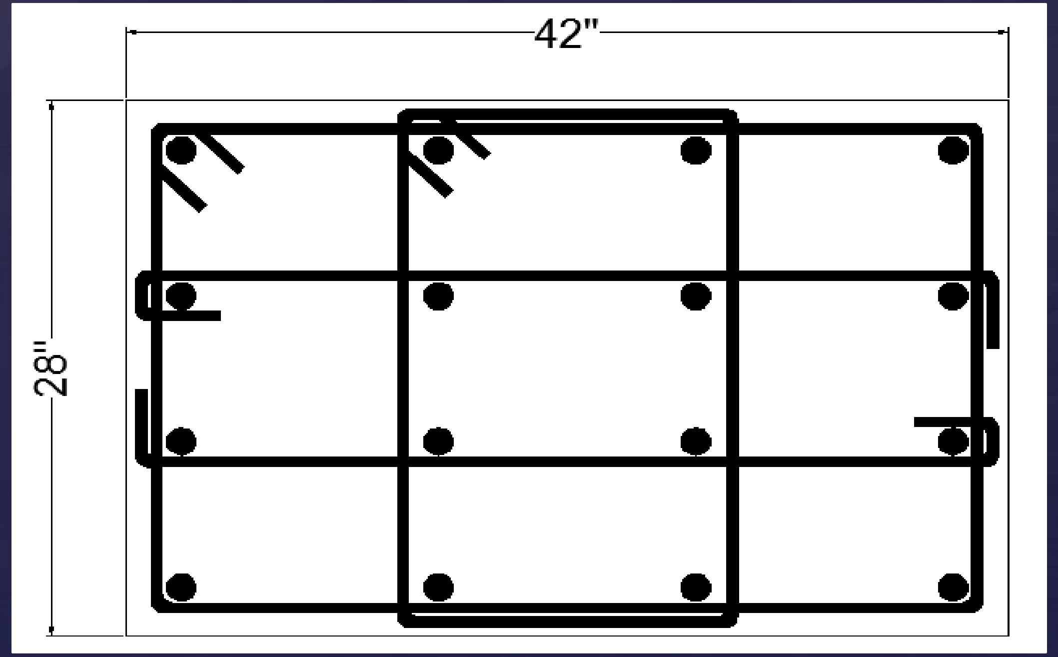
Partial Floor plan of cantilever

Removal of Column Row B

New Column design:

- Original Column A3
  - 44 x 20, (16) # 9 bars
  - Pu = 1555 kips
- New Column A3
  - 48 x 24, (16) #11 bars
  - Pu = 2518 kips, ΦPn = 3464 kips
- Original Column C3
  - 36 x 24, (16) #7 bars
  - Pu = 1520 kips
- New Column C3
  - 42 x 28, (16) #11 bars
  - Pu = 2493 kips, ΦPn = 3517 kips





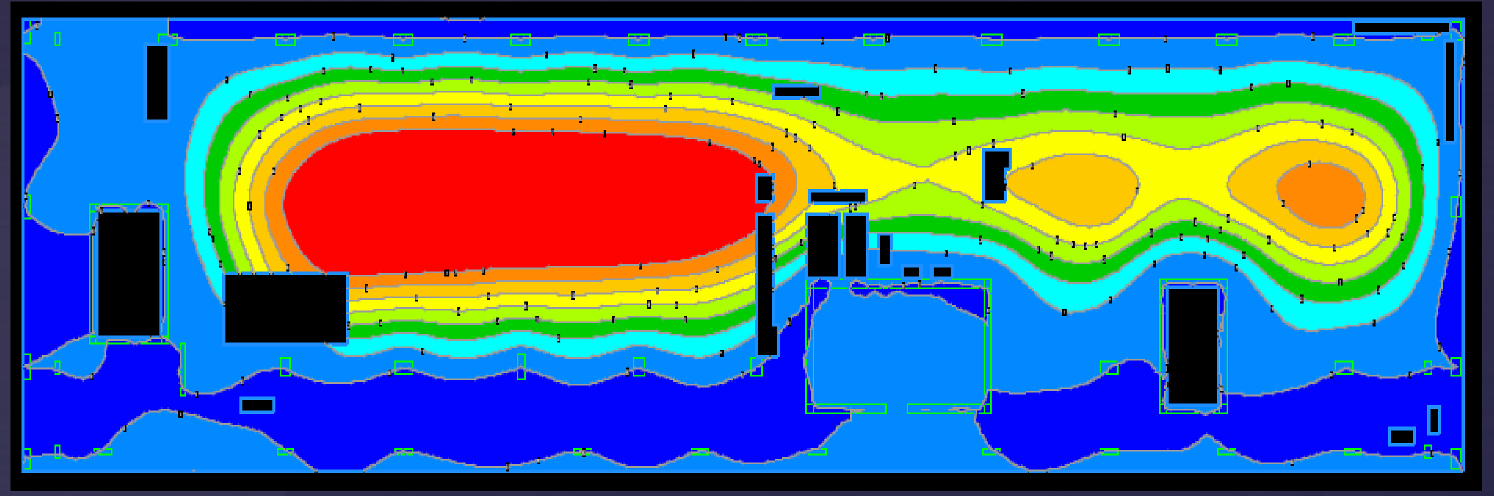
Effects on Floor Systems

Banded Beam

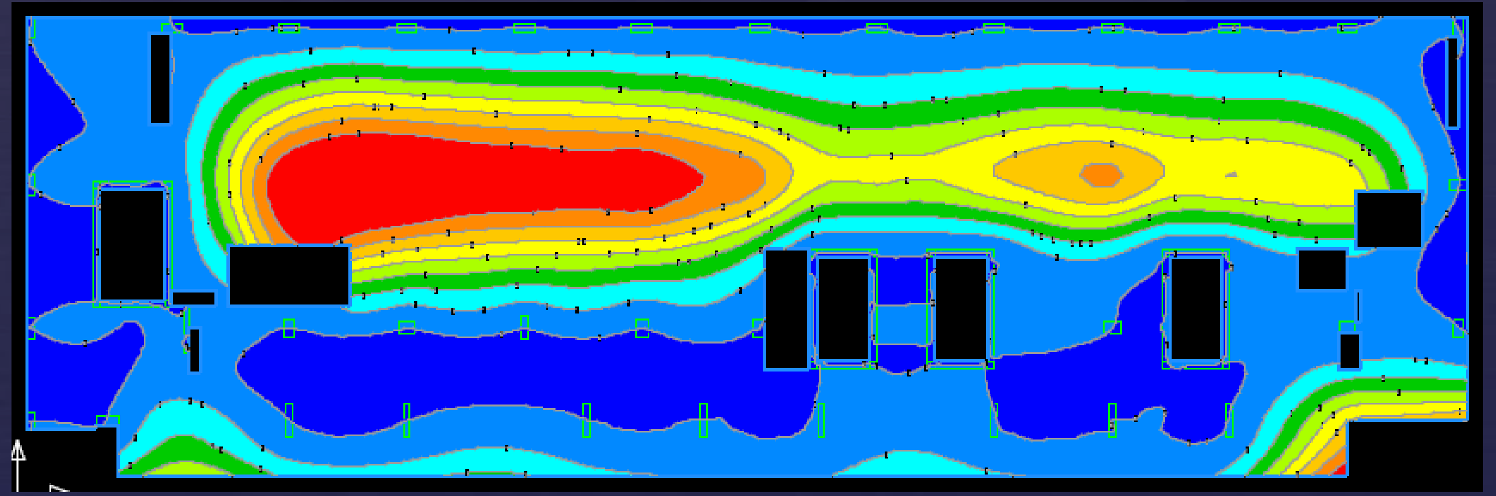
Location	Superimposed Dead Load (psf)	Live Load (psf)	Beam Height (in)	Reinforcement Depth (in)	A_p (in^2)	Tendon Spacing (in O.C.)	M_u (kip-ft)	ϕM_n (kip -ft)
Typical	27	60	14	11.5	11.52	6	1275	1352
Higher Load Areas	47	150	16	13.5	31.10	6	2129	2052
17th Floor	97	150	18	15.5	20.74	6	2461	2705
18th Floor	107	400	24	21.5	20.74	6	4579	4650

Two-Way PT Flat Plate Slab

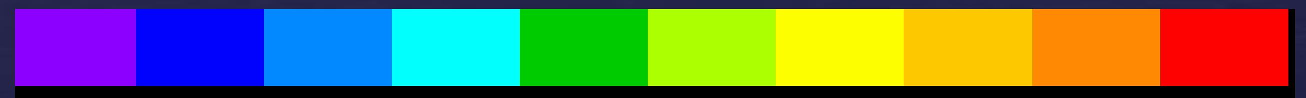
Level	Long. Spacing	Max Deflection (in)	Max Moment (kip-ft)
Typ Floor	3-4 ft	2	1500
17th Floor	4-6 ft	2.5	1700
18th Floor	3-6 ft	2.5	2000

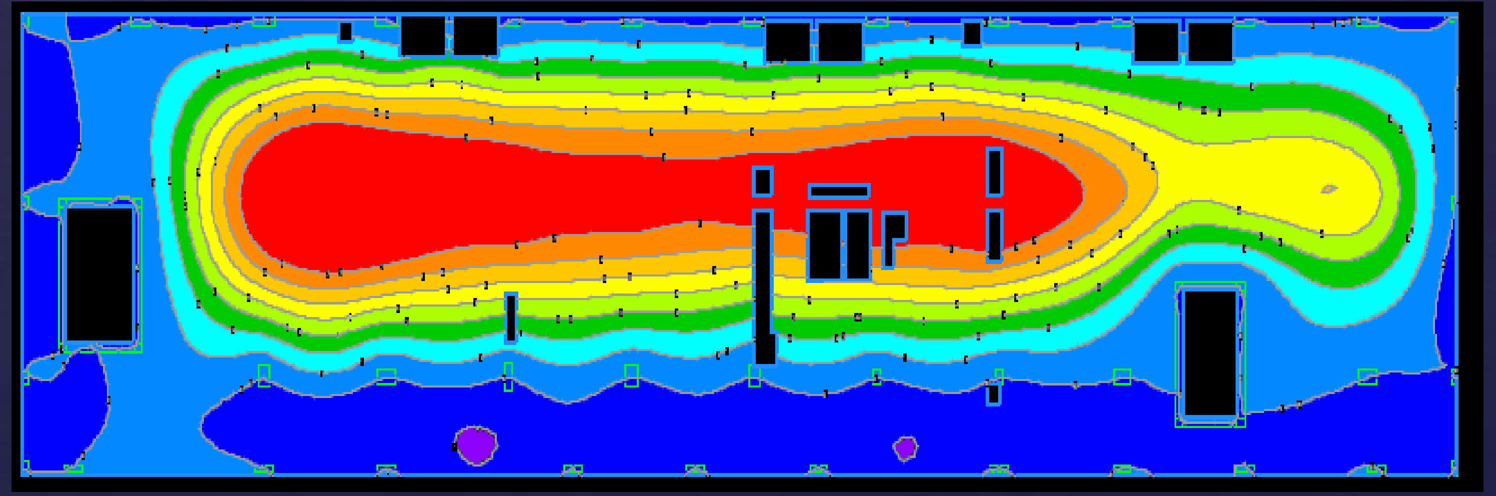


17th Floor



Typical Floor





18th Floor

Structural Depth Summary

Floor System Redesign

- Both systems meet design criteria
- Two-way PT Flat Plate better alternative
    - No camber necessary
    - Floor-to-floor heights reduced
    - Less concrete used

Column Investigations

- 14 x 72: Don’t change
- Remove Row B: Not feasible

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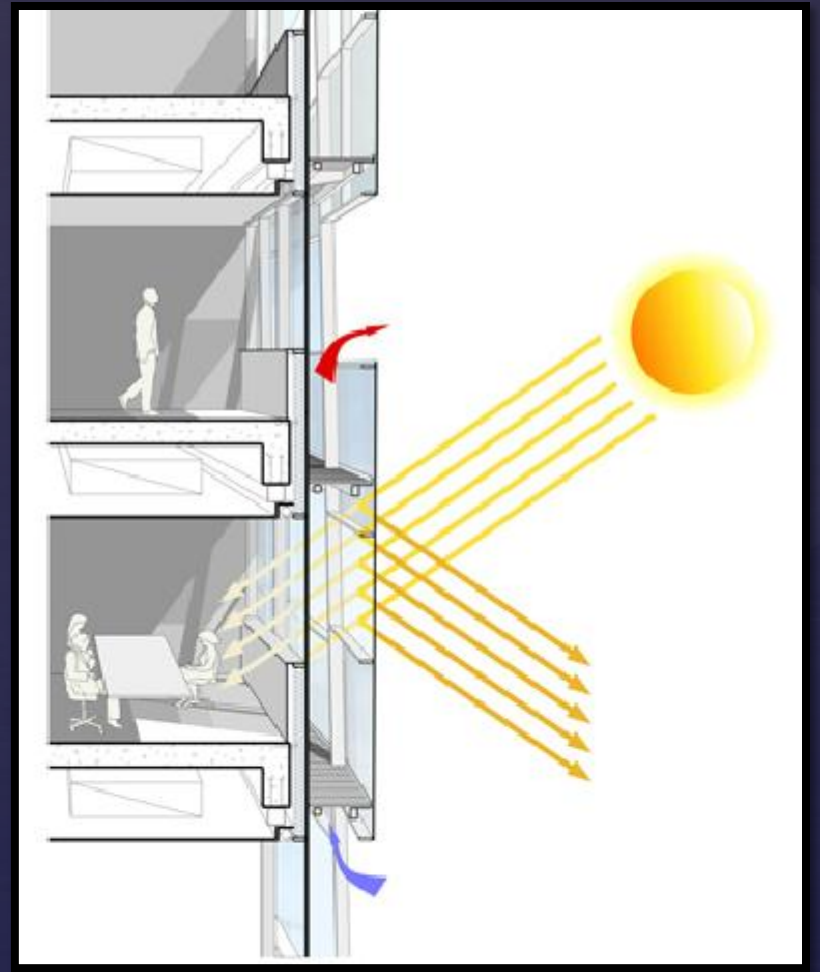
Enclosure Breadth

Glass Sunshade Curtain Wall



View: Front of the building looking up

Images courtesy of Ennead Architects

Brick Cavity Wall

Layers

- 4” brick (Roman)
- 3” air space
- 3” rigid insulation (expanded)
- Air barrier
- Vapor barrier
- 8” concrete wall

Heat Transfer

Wall Materials	R-Value (from H.A.M. Toolbox)	U-Value (1/R)
4" Brick	0.64	1.563
3" Air Space	0.98	1.020
3" Rigid Insulation	11.86	0.084
Building Paper (8mil)	0.12	8.333
Poly Film (6mil)	0.12	8.333
8" Concrete Wall	1.16	0.862
Total R = ΣR =	14.88	
Total U = 1/ΣR =	**0.0672**	
Wall area =	30	m^2
Condition	Temperature (°C)	
Outdoor (Summer)	34	
Outdoor (Winter)	-11	
Indoor (Summer)	24	
Indoor (Winter)	21	
ΔT_{summer}	10	
ΔT_{winter}	-32	
Q = A*U*ΔT	Q (w/m^2*K)	
Summer:	**20.16**	
Winter:	**-63.84**	

Moisture Analysis

Winter

Surface	RH (%)
Outside	80.00
1,2	80.93
2,3	68.94
3,4	12.60
4,5	12.42
5,6	27.41
Inside	25.00

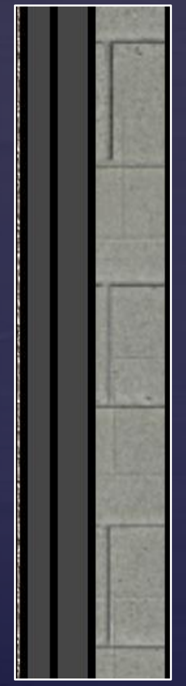
Summer

Surface	RH (%)
Outside	57.00
1,2	56.36
2,3	58.44
3,4	90.92
4,5	91.30
5,6	52.20
Inside	50.00

EIFS Wall

Layers

- 1.25” EIFS
- 2” air space
- 2.5” rigid insulation (extruded)
- Air barrier
- Vapor barrier
- 6” CMU



Heat Transfer

Wall Materials	R-Value (from H.A.M. Toolbox)	U-Value (1/R)
1-1/4" EIFS	4.25	0.235
2" Air Space	0.98	1.020
2-1/2" Rigid Insulation	12.84	0.078
Building Paper (8mil)	0.12	8.333
Poly Film (6mil)	0.12	8.333
6" Concrete Block	0.92	1.087
Total R = ΣR =	19.23	
Total U = 1/ΣR =	**0.0520**	
Wall area =	30	m^2

Condition	Temperature (°C)
Outdoor (Summer)	34
Outdoor (Winter)	-11
Indoor (Summer)	24
Indoor (Winter)	21
ΔT_{summer}	10
ΔT_{winter}	-32

Q = A*U*ΔT	Q (w/m^2*K)
Summer:	**15.60**
Winter:	**-49.40**

Moisture Analysis

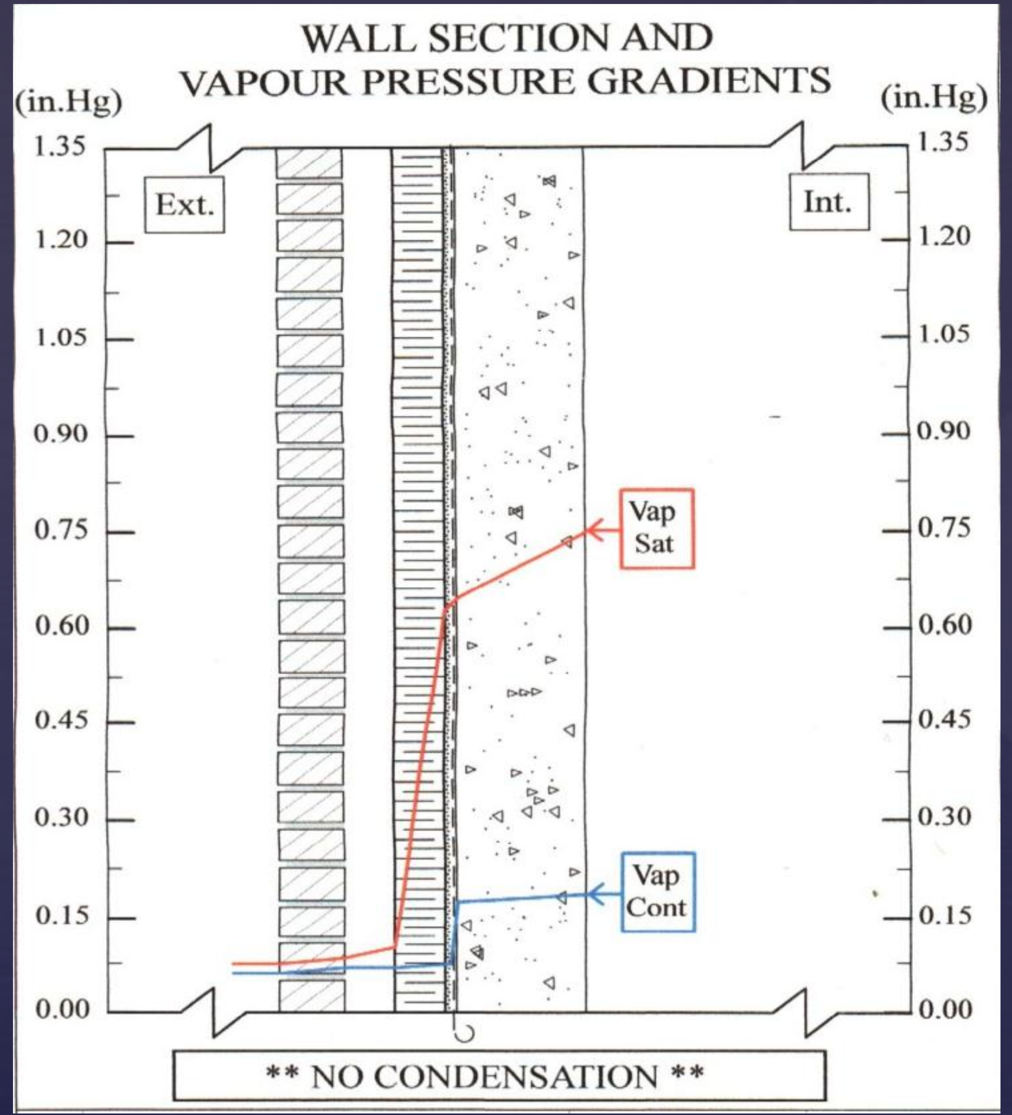
Winter

Surface	RH (%)
Outside	80.00
1,2	48.83
2,3	43.37
3,4	12.28
4,5	12.15
5,6	27.17
Inside	25.00

Summer

Surface	RH (%)
Outside	57.00
1,2	62.30
2,3	64.09
3,4	92.77
4,5	93.06
5,6	53.15
Inside	50.00

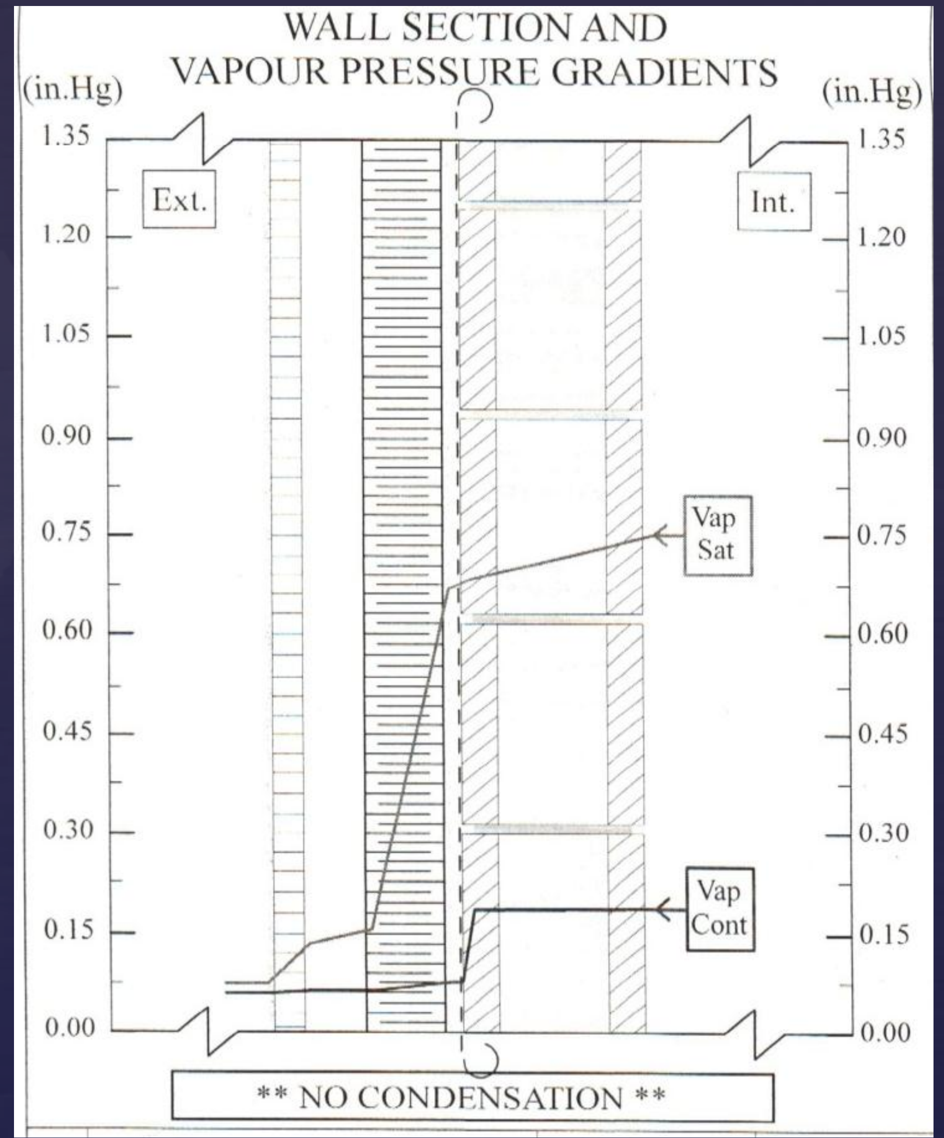
Enclosure Breadth Summary



Brick Cavity Wall (Winter)

Success of Redesign

- Thinner, lighter system
- Decrease heat loss and gain
- Decrease potential for condensation in the air space



EIFS Wall (Winter)

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Conclusions

Structural Depth

- Two floor systems examined
  - Two-Way PT Flat Plate slab deemed best alternative to original design
    - Eliminate camber
    - Minimize floor-to-floor heights
    - Satisfy deflection requirements for cantilever
- Column Investigations
  - Change size of 14 x 72 columns
  - Remove Row B columns
  - Original column layout is best

Enclosure Breadths

- EIFS Wall system designed
- New design compared with original Brick Cavity Wall system
  - More insulating, less heat loss/gain
  - Better for moisture control

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Questions and Comments

Thank You